SN 10/760,541

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 234 026 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 86117342.5

(51) Int. Cl.4: B02C 15/00

(22) Date of filing: 12.12.86

(30) Priority: 24.02.86 US 831948

(43) Date of publication of application: 02.09.87 Bulletin 87/36

(84) Designated Contracting States: BE DE ES FR GB IT NL

(71) Applicant: Combustion Engineering, Inc.
Corporate Patent Counsel
1000 Prospect Hill Road
Windsor Connecticut 06095(US)

(72) Inventor: McKerrow, Campbell
230 Castle Drive, Apt. 46
Bethel Park Pennsylvania 15102(US)
Inventor: Stewart, William Houston, Jr.
53 Boyka Drive
Finleyville Pennsylvania 15332(US)

(74) Representative: Gross, Gernot K.
Kleiberweg 5
D-6200 Wiesbaden(DE)

(54) Articles embodying a wear resistant surface layer and a method of manufacture thereof.

(57) Articles (18, 38, 44, 46, 48) embodying a wear resistant surface layer (34) which are particularly suited for employment in a bowl mill (10) of the type that is operative for purposes of effective the pulverization therewithin of a material such as coal. Among these articles (18, 38, 44, 46, 48) that embody such a wear resistant surface layer (34) are to be found the rolls (18) which provide the grinding force that is employed for purposes of effecting the pulverization within the bowl mill (10) of material such as coal as well as the liners (44, 46, 48) that for wear resistant purposes are employed in selected regions of the interior of the bowl mill (10). As regards the rolls (18), the wear resistant surface layers (34) thereof, as cast, comprise, by weight percentages, 3.2% -3.4% Carbon, 1.45% -1.65% Silicon, 0.4% maximum Manganese, 4.5% -5.0% Nickel, 4.0% -4.25% Chromium, 0.4% -0.5% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum and no Bismuth. On the other hand, insofar as the liners (44, 46, 48) are concerned, the wear resistant surface layers thereof, as cast, comprise, by weight percentages, 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum and 0.015% nominal Bismuth.

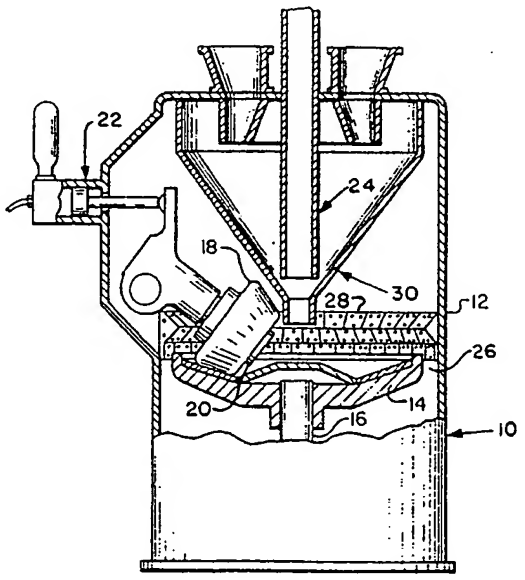

Fig. 1

EP 0 234 026 A2

ARTICLES EMBODYING A WEAR RESISTANT SURFACE LAYER AND A METHOD OF MANUFACTURE THEREOF

BACKGROUND OF THE INVENTION

This invention relates to articles of the type that are designed to be subjected to highly abrasive operating conditions which in turn renders it necessary that such articles have at least the outer surface layers thereof formed of a material which possesses good wear resistant qualities. More specifically, this invention in particular relates both to the grinding rolls which are employed in a pulverizer of the type that is particularly suited to be used to effect the pulverization therewithin of a material such as coal, and to the mill liners that are employed in selected interior regions of the pulverizer.

An essential component of any steam generation system in which coal is utilized as a fuel is obviously the apparatus that is employed for purposes of accomplishing the pulverization of the coal so as to render it suitable for use as a fuel. To this end, one apparatus in particular which has frequently been utilized to accomplish the pulverization of coal so as to render it suitable for use as a fuel in a coal-fired steam generation system is that which those in the industry commonly refer to as a bowl mill. The bowl mill obtains its name principally from the fact that the pulverization, i.e., grinding, of the coal that takes place therewithin occurs on a grinding surface which in configuration bears a resemblance somewhat to that of a bowl.

In connection with the discussion that follows, particular reference is made herein to the fact that two of the essential components of such a bowl mill are one the body portion, i.e., housing, within which the grinding surface, i.e, grinding table, from which the bowl mill derives its name is mounted for rotation, and two the plurality of grinding rolls that are supported in equally spaced relation one to another within the housing of the bowl mill so as to be able to coact with the grinding table such that the coal disposed on the surface of the grinding table is capable of being ground, i.e., pulverized, as a consequence of the grinding force that the plurality of grinding rolls apply to the coal. For this purpose the grinding rolls are each designed to be mounted on a shaft-like member. Furthermore, in order to effect the assembly of the grinding roll with the aforesaid shaft-like member, the grinding roll preferably has a through passage provided through the center thereof. This through passage enables the shaft-like member to be positioned therewithin so that the grinding roll is thereby positioned in mounted relation thereto. In order, therefore, to facilitate the task of providing the grinding roll with such a through passage, it is desirable that the grinding roll be made of a material that is characterized by its ease of machinability, i.e., a relatively soft material such as gray iron.

In contradistinction to the desirability of forming the grinding roll from a relatively soft material, there also exists a requirement that at least the external, i.e., outer, surface layer of the grinding roll be of a material that is characterized by its good wear resistant qualities. The reason for this is that in the course of effecting the pulverization of material with these grinding rolls, the latter are of necessity subjected to a harsh abrasive action by virtue of the nature of the material being pulverized as well as by virtue of the manner in which the pulverization takes place. The result thus is that the grinding rolls are susceptible to being rendered unusable because of excessive wear in a relatively short period of time, i.e., the rolls are found to have a relatively short operating life. Obviously, such a result is to be avoided, if possible. In this context, note is made of the fact that the wear which grinding rolls employed in bowl mills actually experience is influenced principally by the grinding characteristics of the material that is being pulverized as well as by the productive output of the bowl mill, i.e., the amount of material that is being pulverized within the bowl mill in a given period of time.

When the outer surface layer of the grinding, i.e., pulverizer, roll becomes sufficiently worn so as to preclude the further use thereof for purposes of accomplishing therewith the pulverization of material, the remaining portions of the roll normally are still usable. Namely, but for the fact that the outer surface layer thereof is worn, the grinding roll would still be capable of being utilized. As such, it is, therefore, not surprising to find in the prior art evidence of the fact that there have been various efforts undertaken in the prior art heretofore directed towards realizing improvements in the wear life of grinding rolls.

For ease of reference, it is possible to classify into three basic categories the efforts that have heretofore been undertaken in an attempt to realize improvements in the wear life of grinding rolls. First, there are the efforts which have been directed towards realizing improvements in the manner in which the original manufacture of the grinding rolls is accomplished and/or in the manner in which the grinding rolls are resurfaced after having become worn. Secondly, there are the efforts which have been directed towards producing an improved

high chromium alloy that is capable of being utilized for purposes of fabricating therefrom at a minimum, the wear surface, i.e., the outer surface layer, of the grinding rolls. Thirdly, there are the efforts which have been directed towards producing an improved nickel-chromium alloy that is capable of being utilized for purposes of fabricating therefrom at a minimum, the wear surface, i.e., the outer surface layer, of the grinding rolls.

Insofar as the first of the categories which have been enumerated above is concerned, reference may be had in this regard, by way of exemplification and not limitation, to U.S. Patent No. 4,389,767, which issued on June 28, 1983, and which is assigned to the same assignee as the present application. U.S. Patent No. 4,389,767 discloses a method of manufacturing a grinding roll which is characterized in that the wear surface, i.e. the outer surface layer, of the grinding roll is shaped in accordance with the predicted wear characteristics that the grinding roll is expected to experience based on the nature of the use to which the grinding roll is intended to be put such that the contour thereof replicates that of a worn grinding roll, and a substantially uniform layer of a material characterized by its wear resistant qualities is applied to the outer surface of the grinding roll so as to form the wear surface of the grinding roll.

A further illustration of the prior art efforts which are deemed to fall into the first of the categories that have been enumerated above is that which forms the subject matter of U.S. patent application Serial No. 764,802. The latter U.S. patent application bears a filing date of August 12, 1985, and is assigned to the same assignee as the present application. To this end, U.S. patent application Serial No. 764,802 is directed to a trimetal grinding roll which embodies a trimetal form of construction and wherein the core material, i.e., the first or inner layer, of the trimetal roll consists of a relatively soft material that is noted for its good machinability, the next, i.e., second or intermediate, layer of the trimetal roll comprises a material that has medium wear resistant qualities and the last, i.e., third or outer, layer of the trimetal roll comprises a material having highly abrasive resistant qualities.

Attention will next be focused on a second category, as enumerated above, of the prior art efforts that have been undertaken heretofore in an attempt to improve the wear life of the grinding rolls that are employed in a bowl mill. By way of exemplification and not limitation, reference is had here to one such particular effort. More specifically, the effort to which reference is had here is that which culminated in the development of the material known to those in the industry as "Stoody 103". This material, i.e., Stoody 103, has been available for purchase from The Stoody Company of California. Reportedly, the composition of Stoody 103 material is such that among others, this material includes in the approximate amounts, by weight percentages, set forth hereinafter the following elements: Carbon -4.0%, Manganese -5.0%, and Chromium -27.0% to 28.0%. On the other hand, Stoody 103 material is said to include neither molybdenum nor boron, except perhaps in quantities which are barely discernible. Insofar as the fabrication of grinding rolls is concerned, the material known as Stoody 103 most commonly is employed in the form of a weld overlay that is applied to the grinding roll so as to comprise the outer surface thereof, i.e., so that the layer of Stoody 103 material which is applied thereto forms the wear surface of the grinding roll. It has been alleged that the wear resistant qualities of Stoody 103 material are, by a factor of one and one-half to two times, better than those of the material which for ease of reference is referred to hereinafter as ordinary Nihard.

Another example of a prior art effort which can be classified into the second category, as these categories have been enumerated hereinbefore, of prior art efforts that have been undertaken in an attempt to improve the wear life of the grinding rolls of a bowl mill is that which resulted in the development of the material that forms the subject matter of the International patent application which bears the Application Number PCT/US82/00976. The latter International patent application is directed to an abrasion resistant white cast iron. More specifically, the white case iron which forms the subject matter of the aforereferenced International patent application is defined therein as comprising a base of iron, and, by weight percentages, 2.0% - 4.5% Carbon, .001% -4.00% Boron and one or more of the following alloying elements: .001% -30% Vanadium, Titanium, Niobium, Tantalum, Molybdenum, Nickel, Copper, or Chromium, or mixtures thereof.

Yet another example of those prior art efforts which are deemed to fall within the second category thereof, as the categories have been enumerated hereinbefore, is that which led to the development of the highly abrasion resistant alloy which forms the subject matter of the copending U.S. patent application that bears the Serial No. 703,160 and that was filed on February 19, 1985, and which is assigned to the same assignee as the present application. U.S. patent application Serial No. 703,160 is directed to an alloy that is characterized by its highly abrasion resistant qualities which in turn renders it particularly suitable for use as the material from which to fabricate the outer surface layer, i.e., the wear surface of a grinding, i.e., pulverizer, roll that is designed to be employed

in a bowl mill so as to be operative therein for purposes of accomplishing the pulverization of a material such as coal through the coaction of the grinding roll with another surface with which the bowl mill is suitably provided for this purpose. The highly abrasion resistant alloy to which reference is had here comprises, by weight percentages, 4.0% -6.0% Carbon, 3.0% -14.0% Manganese, 1.0% - 2.5% Silicon, 15.0% -30.0% Chromium, and 4.0% - 6.0% Molybdenum, with 0.5% -2.0% Boron being added thereto, the balance being iron and incidental impurities. Based on test results that have been conducted to date, the highly abrasion resistant alloy to which U.S. patent application Serial No. 703,160 is directed is predicted to have twice the wear life of that of a prior art form of standard hardfacing material such as the material previously discussed herein known as Stoody 103.

Moving on to a consideration of a third category, as the categories have been enumerated hereinabove, of the prior art efforts that have been undertaken heretofore in an attempt to improve the wear life of the grinding rolls of a bowl mill, reference is had here, by way of exemplification and not limitation, to U.K. patent application GB 2,027,702A. It has long been known to those skilled in this art to fabricate the outer surface layer, i.e., the wear surface, of the grinding rolls of the type that are employed in a bowl mill from that material which is commonly referred to as Nihard. U.K. patent application GB 2,027,702A, on the other hand, is directed to a white cast iron alloy, which the assignee of this application, i.e., Sheepbridge Equipment Limited of the United Kingdom, has seen fit to refer to as "Premium Nihard". Allegedly, the latter alloy has better wear resistant qualities than that of what is being referred to herein as ordinary Nihard, i.e., that material which those skilled in this art have long referred to as Nihard. As described therein, the white cast iron alloy, i.e., Premium Nihard, to which U.K. patent application GB 2,027,702A is directed comprises, by weight percentages, 2.8% -3.5% Carbon, 0.6% -2.0% Silicon, 0.05% -0.5% Manganese, 0.05% -0.25% Sulfur, 0.5% -1.5% Phosphorus, 3.5% -5.0% Nickel, 2.5% -4.5% Chromium, 0.2% -0.7% Molybdenum, with the balance being iron and incidental impurities. Further, it is to be found stated in U.K. patent application GB 2,027,702A that the white cast iron alloy, which forms the subject matter of this patent application, may also contain up to .01% Bismuth, by weight percentage, to ensure against possible graphite formation particularly in heavy section castings.

A major reason why the attainment of a longer operating life for new grinding rolls is sought is that it would enable one to extend the point in time at which it becomes necessary to shut down the bowl mill for purposes of enabling the removal therefrom of the worn grinding roll and the replacement thereof with an unworn grinding roll. In this regard, it is important to note that a plurality of bowl mills are commonly employed to provide the required amount of pulverized coal to a coal-fired steam generator, and that each of these bowl mills normally embodies three grinding rolls that are each susceptible to having to be removed and replaced as they become worn. Also, there is the matter of the time and effort as well as the cost associated therewith that needs to be expended in the course of effecting such removal and replacement of a worn grinding roll. Obviously, therefore, if one were able to reduce the frequence with which grinding rolls become sufficiently worn as to require replacement, cost savings could be realized in terms of the time and effort that is required to be expended to effect such replacement.

Apart from the grinding rolls which have been the subject of discussion in the preceding paragraph, there are also a number of other components of a bowl mill that are equally likely during the operation of the bowl mill to be subjected to wear. By way of exemplification and not limitation, reference is had here in this regard to the upper surface of the grinding table, which as was mentioned herein previously, is designed to coact with the grinding rolls such that through the coaction therebetween material such as coal which is disposed on the upper surface of the grinding table becomes pulverized as a consequence of the force being applied thereto by the grinding rolls. Continuing, other components of the bowl mill which are known to be prone to suffer from wear are those which lie in the path of movement that the coal particles follow as they are being conveyed by a gas such as air through the interior of the bowl mill. More specifically, the components to which reference is had here suffer wear by virtue of the abrasive action to which they are subjected when they are struck by the coal particles as the latter are being transported through the interior of the bowl mill. To this end, it has long been known to selectively emplace liners in those regions of the interior of the bowl mill where from past experience wear has most frequently occurred.

Insofar as the upper surface of the grinding table of the bowl mill is concerned, this upper surface commonly takes the form of what is known to those skilled in this art as a bull ring. In accord with the teaching of the prior art the bull ring has been known to be formed as an integral member as well as in the form of a multiplicity of individual segments which collectively comprise the bull ring. The bull ring is designed to be suitably supported on the grinding table so as to be rotatable therewith. The mode of operation of the grinding table of

the bowl mill is such that the material to be pulverized is fed in a suitable manner on to the bull ring. Then, as the grinding table and thereby also the bull ring rotates by the grinding rolls the material that is disposed on the bull ring becomes pulverized by virtue of the force applied thereto by the grinding rolls as the bull ring is made to rotate past the grinding rolls.

After being pulverized in the aforedescribed manner, the coal particles are then picked up and become entrained in a stream of air that flows upwardly around the circumference of the grinding table. Once entrained in this stream of air the coal particles are conveyed in suitable fashion through the interior of the bowl mill. In the course of being so conveyed, those coal particles which are larger than desired are made to return to the grinding table for further pulverization, whereas those coal particles which are of the desired size continue their passage through the interior of the bowl mill and eventually exit therefrom. It is while the coal particles are being conveyed in this fashion that the components housed within the interior of the bowl mill are struck thereby which in turn occasions the wear to which reference has been had hereinbefore.

A need has thus been demonstrated in the prior art for articles having at least the outer surface layers thereof formed of a new and improved material which is characterized by its highly abrasion resistant qualities. In addition, a need has been evidenced for such a highly abrasion resistant material which, at a minimum, would be suitable for employment as the outer surface layer, i.e., the wear surface, of a grinding roll and which would in turn enable a grinding roll to be provided that would be characterized by the fact that the grinding roll possesses an improved wear life. Moreover, there has been evidenced a need for such a highly abrasion resistant material which would be suitable for employment for purposes of resurfacing a worn grinding roll wherein the highly abrasion resistant material would, at a minimum, form the outer surface layer, i.e., the wear surface, of the grinding roll. Such a highly abrasion resistant material should be suitable for employment for resurfacing a worn grinding roll notwithstanding the nature of the material which had originally been utilized as the outer surface layer, i.e., wear surface, of the grinding roll. Further, such a highly abrasion resistant material should be suitable for employment to form the bull ring that is designed to be emplaced on the grinding table of the bowl mill irrespective of whether the bull ring is intended to be in the form of an integral member or in the form of a multiplicity of individual segments. Also, such a highly abrasion resistant material should be suitable for employment for purposes of forming therefrom the liners that are designed to be selectively emplaced in those regions of the interior of the bowl mill that are known to be susceptible to wear of the type that is occasioned by the coal particles striking thereagainst in the course of their passage through the bowl mill interior while entrained in a fluid medium such as air.

It is, therefore, an object of the present invention to provide articles that embody a wear resistant surface layer formed of a new and improved material that is characterized by its good wear resistant qualities.

It is another object of the present invention to provide such articles embodying a wear resistant surface layer that are particularly suited for employment in a bowl mill of the type which is designed to be utilized for purposes of effecting the pulverization therewithin of a material such as coal.

It is still another object of present invention to provide such articles embodying a wear resistant surface layer wherein the articles include the grinding rolls which are designed to be employed in a bowl mill.

A further object of the present invention is to provide such articles embodying a wear resistant surface layer wherein the articles include the bull ring which is designed to be emplaced on the grinding table of the bowl mill.

Yet another object of the present invention is to provide such articles embodying a wear resistant surface layer wherein the articles include the liners which are designed to be selectively emplaced in those regions of the bowl mill that based on prior experience are known to be susceptible to wear.

Yet still another object of the present invention is to provide such articles embodying a wear resistant surface layer wherein the articles are relatively inexpensive to provide, are relatively easy to employ, and are characterized by their improved wear life.

SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention there are provided grinding rolls of the type that are particularly suited for employment in a bowl mill wherein the grinding rolls provide the grinding force which is employed for purposes of effecting the pulverization within the bowl mill of material such as coal. The subject grinding rolls each embody a wear resistant surface layer which, as cast, comprises, by weight percentages, 3.2% - 3.4% Carbon, 1.45% -1.65% Silicon, 0.4% maximum Manganese, 4.5% -5.0% Nickel, 4.0% - 4.25% Chromium, 0.4% -0.5% Phosphorus, 0.9% - 0.11% Sulfur, 0.4% -0.6% Molybdenum and no Bismuth.

In accordance with another aspect of the present invention there is provided a bull ring of the type that is designed to be emplaced on the grinding table of a bowl mill, the latter being operative for purposes of accomplishing the pulverization therewithin of material such as coal. The subject bull ring embodies at least a wear resistant surface layer which, as cast, comprises, by weight percentages 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum and 0.015% nominal Bismuth.

In accordance with yet another aspect of the present invention there are provided liners of the type that are designed to be selectively emplaced in those regions which are susceptible to wear of the interior of a bowl mill, the latter being operative for purposes of accomplishing the pulverization therewithin of a material such as coal. The subject liners each embody at least a wear resistant surface layer which, as cast, comprises, by weight percentages 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum and 0.015% nominal Bismuth.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a side elevational view partially in section and with some parts broken away of a bowl mill embodying articles constructed in accordance with the present invention having at least the outer surface layer thereof formed of a material characterized by its good wear resistant qualities;

Figure 2 is a sectional view on an enlarged scale of a bowl mill grinding roll embodying an outer surface layer formed of a material characterized by its good wear resistant qualities constructed in accordance with the present invention;

Figure 3 is a sectional view of a bull ring embodying an outer surface layer formed of a material characterized by its good wear resistant qualities constructed in accordance with the present invention and illustrated emplaced on the grinding table of a bowl mill;

Figure 4 is a top plan view of a first type of bowl mill liner embodying an outer surface layer formed of a material characterized by its good wear resistant qualities constructed in accordance with the present invention;

Figure 5 is a side elevational view of a second type of bowl mill liner embodying an outer surface layer formed of a material characterized by its good wear resistant qualities constructed in accordance with the present invention; and

Figure 6 is a sectional view of a third type of bowl mill liner embodying an outer surface layer formed of a material characterized by its good wear resistant qualities constructed in accordance with the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawing, and more particularly to Figure 1 thereof, there is depicted therein a bowl mill, generally designated by reference numeral 10. Inasmuch as the nature of the construction and the mode of operation of bowl mills per se are well-known to those skilled in the art, it is not deemed necessary, therefore, to set forth herein a detailed description of the bowl mill 10 illustrated in Figure 1. Rather, it is deemed sufficient for purposes of obtaining an understanding of a bowl mill 10, which is capable of being equipped with articles embodying in accordance with the present invention an outer surface layer formed of a material characterized by its good wear resistant qualities, that there be presented herein merely a generalized description of the nature of the construction and the mode of operation of the components of the bowl mill 10. For a more detailed description of the nature of the construction and the mode of operation of the components of the bowl mill 10, which are not described in detail herein, one may have reference to the prior art, e.g., U.S. Patent No. 3,465,971, which issued September 9, 1966 to J. F. Dalenberg et al, and/or U.S. Patent No. 4,002,299, which issued January 11, 1977 to C. J. Skalka.

Referring further to Figure 1 of the drawing, the bowl mill 10 as illustrated therein includes a substantially closed separator body 12. A grinding table 14 is mounted on a shaft 16, which in turn is operatively connected to a suitable drive mechanism (not shown) so as to be capable of being rotatably driven thereby. With the aforereferenced components arranged within the separator body 12 in the manner depicted in Figure 1 of the drawing, the grinding table 14 is designed to be driven in a clockwise direction.

Continuing with a description of the bowl mill 10, a plurality of grinding, i.e., pulverizer, rolls 18, preferably three in number in accord with conventional practice, are suitably supported within the interior of the separator body 12 so as to be spaced equidistantly one from another around the circumference of the latter. Note is made here of the fact that in the interest of maintining clarity of illustration in the drawing only one grinding roll has been depicted in Figure 1.

With further regard to the grinding rolls of the bowl mill 10, each of the latter as best understood with reference to the grinding roll 18 depicted in Figure 1 of the drawing is preferably supported on a suitable shaft, seen at 20 in Figure 1, for rotation relative thereto. In addition, each of the grinding rolls, as best understood with reference to the grinding roll 18 of Figure 1 is also suitably supported for movement relative to the upper surface, as viewed with reference to Figure 1, of the grinding table 14. To this end, each of the grinding rolls of the bowl mill 10 including the roll 18 illustrated in Figure 1 has a hydraulic means, generally designated in Figure 1 by the reference numeral 22, cooperatively associated therewith. The hydraulic means 22 in a manner well-known to those skilled in the art of bowl mills is operative to establish a hydraulic loading on the grinding roll 18 associated therewith whereby the latter grinding roll 18 is made to exert the requisite degree of force on the coal that is disposed on the grinding table 14 for purposes of accomplishing the desired pulverization of this coal.

The material, e.g., coal, that is to be pulverized in the bowl mill 10 is fed thereto by means of any suitable conventional form of feed means. By way of exemplification in this regard, one such feed means that may be employed for this purpose is a belt feeder means (not shown). Upon being discharged from the feed means (not shown), the coal enters the bowl mill 10 by means of a coal supply means, generally designated by reference numeral 24, with which the separator body 12 is suitably provided. The coal supply means 24 is operative to cause the coal to flow on to the surface of the grinding table 14.

In accord with the mode of operation of bowl mills that embody the form of construction depicted in Figure 1, a gas such as air is utilized to effect the conveyance of the coal from the grinding table 14 through the interior of the separator body 12 for discharge from the bowl mill 10. The air that is used in this regard enters the separator body 12 through a suitable opening (not shown) formed therein for this purpose. From the aforesaid opening (not shown) in the separator body 12 the air flows to and through the annulus, the latter being denoted in Figure 1 by the reference numeral 26, which consists of the ring-like space that exists between the circumference of the grinding table 14 and the inner wall surface of the separator body 12. The air upon passing through the annulus 26 is deflected over the grinding table 14 preferably by means of a vane wheel assembly, constructed in accordance with the teachings of U.S. Patent No. 4,523,721 which issued on June 18, 1985 to T. V. Maliszewski et al, and which is assigned to the same assignee as the present application. For purposes of maintaining clarity of illustration in the drawing, only the deflector portion, the latter being seen at 28 in Figure 1, of the vane wheel assembly which forms the subject matter of U.S. Patent No. 4,523,721 has been depicted in the drawing. Moreover, it is deemed that the depiction of the deflector portion 28 in Figure 1 of the drawing is sufficient for purposes of enabling one to obtain a complete understanding of the subject matter of the present invention to which the instant application is directed. However, should further information be desired concerning the nature of the construction and/or the mode of operation of the vane wheel assembly that the bowl mill 10 shown in Figure 1 embodies, reference may be had for this purpose to U.S. Patent No. 4,523,721.

While the air is flowing along the path described above, the coal which is disposed on the surface of the grinding table 14 is being pulverized by the action of the grinding rolls 18. As the coal becomes pulverized, the particles are thrown outwardly by centrifugal force away from the center of the grinding table 14. Upon reaching the region of the circumference of the grinding table 14, the coal particles are picked up by the air exiting from the annulus 26 and are carried along therewith. The combined flow of air and coal particles is thereafter captured by the deflector portion 28 of the vane wheel assembly constructed in accordance with the teachings of U.S. Patent No. 4,523,721. The effect of this is to cause the combined flow of this air and coal particles to be deflected over the grinding table 14. This necessitates a change in direction in the path of flow of this combined stream of air and coal particles. In the course of effecting this change of direction, the heaviest coal particles, because they have more inertia, become separated from the air stream, and fall back on to the surface of the grinding table 14 whereupon they undergo further pulverization. The lighter coal particles, on the other hand, because they have less inertia continue to be carried along in the air stream.

After leaving the influence of the aforesaid deflector portion 28, the combined stream consisting of air and those coal particles that remain flows to the classifier 30. The classifier 30 in accord with conventional practice and in a manner which is well-known to those who are skilled in this art operates to effect a further sorting of the coal particles that remain in the air stream. Namely, those particles of pulverized coal, which are of the desired particle size, pass through the classifier 30 and along with the air are discharged therefrom and thereby from the bowl mill 10. On the other hand, those coal particles, which in size are larger

than desired, are returned to the surface of the grinding table 14 whereupon they undergo further pulverization. Thereafter, these coal particles are subject to a repeat of the process described above.

With further regard to the matter of the pulverizing, i.e., grinding, action to which the coal disposed on the grinding table 14 is subjected by the grinding rolls 18, the amount of force that must be exerted by the latter in order to effect the desired degree of pulverization of the coal will vary depending on a number of factors. For example, one important consideration in this regard is the nature of the coal itself. That is, the amount of force required to pulverize the coal will be a function of the grindability of the coal to be pulverized, i.e., the grinding characteristics of the latter. Another important factor in determining the amount of force that the grinding rolls 18 must exert to accomplish the desired degree of pulverization of the coal is the depth to which the coal is disposed on the grinding table 14, which in turn is a function of the output rate at which the bowl mill 10 is being operated.

For purposes of setting forth a detailed description of a bowl mill grinding roll which embodies an outer surface layer formed of a material characterized by its good wear resistant qualities and which is constructed in accordance with the present invention, reference will be had in particular to Figure 2 of the drawing. Note is made here of the fact that Figure 2 is intended simply to provide a general illustration of the nature of the construction which a grinding, i.e., pulverizer, roll 18 often embodies. Referring to Figure 2, it will be readily apparent therefrom that the grinding roll 18 often consists of a main body portion, generally designated by reference numeral 32, that embodies the overall configuration of a roll, and a layered external surface 34 formed of a different material, e.g., a material which in accordance with the present invention is characterized by its good wear resistant qualities, than that from which the body portion 32 is formed. To this end, the body portion 32 is preferably made of a relatively soft, easily machinable material such as gray iron, while the outer surface layer 34 is made of a relatively hard material which has good wear resistant qualities, i.e., exhibits good abrasion resistant characteristics. Further, as best understood with reference to Figure 2, the body portion 32 has a through passage 36 formed through substantially the center thereof. The through passage 36 is suitably dimensioned so as to be capable of receiving therewithin in assembled relation thereto the shaft 20 to which reference has previously been had hereinbefore, and on which the grinding roll 18 is suitably supported so as to be capable of functioning in the manner described above and as shown in Figure 1.

In essence, the reasons for fabricating the grinding roll 18 from two dissimilar materials is to give equal recognition to first the fact that there is a need to provide the body portion 32 with the through passage 36 and secondly to the fact that the outer surface 34 is subjected to a hard abrasive action in the course of effecting the pulverization of coal. The result, therefore, is that on the one hand it is desirable that the body portion 32 be made of a relatively soft, easily machinable material so as to facilitate the formation therein of the through passage 36. In contradistinction to this, there is a need for at least the outer portion, i.e., that encompassed by the outer surface layer 34, to be made of a relatively hard material characterized by its capability to resist wear, and in particular the wear caused by abrasive action.

With the preceding discussion serving as a proper background for an understanding of the invention, the outer surface layer 34 of the grinding roll 18 in accordance with the present invention is formed of a material which embodies abrasion resistant qualities and which is particularly suited to be employed for purposes of forming therefrom the outer surface layer, i.e. the wear surface, 34 of the grinding roll 18. Moreover, the material from which the outer surface layer 34 of the grinding roll 18 is formed in accordance with the present invention is further characterized in that it is capable of being cast as well as being it is capable of being utilized to hardface a new grinding roll 18. Typically, the material from which the outer surface layer 34 of the grinding roll 18 is formed, as cast, comprises, by weight percentages, 3.2% -3.4% Carbon, 1.45% -1.65% Silicon, 0.4% maximum Manganese, 4.5% -5.0% Nickel, 4.0% - 4.25% Chromium, 0.4% - 0.5% Phosphorus, 0.9% -0.11% Sulfur, 0.4% - 0.6% Molybdenum and no Bismuth.

Turning next to a consideration of the bull ring which is designed to be emplaced on the grinding table 14 of the bowl mill 10 and which embodies at least an outer surface layer that is characterized by its good wear resistant qualities and is constructed in accordance with the present invention, reference will be had for this purpose in particular to Figure 3 of the drawing. With reference to Figure 3, the bull ring which is denoted therein generally by the reference numeral 38 is formed of a material that is characterized by its good abrasion resistant qualities. More specifically, the bull ring 38 embodies a first portion, the latter being denoted by the reference number 40 in Figure 3, and a second portion which is identified by the reference number 42 in Figure 3. The first portion 40 is suitably inclined relative to the second portion 42 of the bull ring 38 so as to mate with the outer surface layer 34 of the grinding roll 18. That is, the angle at which the first portion 40 of the bull ring 38 is inclined is suitably

selected so as to conform to the angle at which the outer surface layer 34 of the grinding roll 18 is inclined, i.e., the angle at which the first portion 40 of the bull ring 38 is inclined is designed to be complementary to the angle of inclination of the outer surface layer 34 of the grinding roll 18. In accord with the best mode embodiment of the invention, the bull ring 38 preferably is comprised of a multiplicity of individual segments. However, it is to be understood that the bull ring 38 could equally well without departing from the essence of the present invention take the form of a single integral member. Typically, the material from which the bull ring 38 of the grinding roll 18 is formed, as cast, comprises, by weight percentages, 3.5% - 3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum and 0.015% nominal Bismuth.

For purposes of completing the description of the articles embodying in accordance with the present invention an outer surface layer characterized by its abrasion resistant qualities, reference will be had in particular to Figures 4, 5 and 6 of the drawing wherein there is to be found depicted a first type of bowl mill liner identified generally by reference numeral 44 in Figure 4, a second type of bowl mill liner identified generally by the reference numeral 46 in Figure 5, and a third type of bowl mill liner identified generally by the reference numeral 48 in Figure 6. The bowl mill liner 44 constructed as depicted in Figure 4 of the drawing is designed to be employed in the deflector portion 28 of the vane wheel assembly to which reference has been had hereinbefore in connection with the discussion of the bowl mill 10 shown in Figure 1. More specifically, in accordance with the mode of construction of the deflector portion 28, a plurality of bowl mill liners 44 are utilized to form each of the various rows of deflector liners with which the deflector portion 28 is suitably provided. To this end, each of the bowl mill liners 44 embodies a configuration which is preestablished in order to enable each of the bowl mill liners 44 to be cooperatively associated one with another in a suitable fashion as required in order to function as an operative component of the deflector portion 28. That is, as best understood with reference to Figure 4 of the drawing, the bowl mill liner 44 embodies a configuration wherein two sides thereof, i.e., those denoted by the reference numerals 44a and 44b in Figure 4, extend substantially in parallel relation one to another, a third side thereof, i.e., the side denoted by the reference numeral 44c in Figure 4, extends substantially at right angles to both the sides 44a and 44b of the bowl mill liner 44, and the fourth side thereof, i.e., the side denoted by the reference numeral 44d in Figure 4, is inclined relative to both the sides 44a and 44b and in addition extends in nonparallel relation to the side 44c of the bowl mill liner 44. Further, the edge surfaces of the bowl mill liner 44 of Figure 4 are suitable configured such as by being beveled so as to enable them to mate with the complementary edge surfaces of the bowl mill liners 44 that adjoin thereto. This is not only to facilitate the initial installation of the bowl mill liners 44 within the separator body 12 of the bowl mill 10 of Figure 1, but also to facilitate their removal and subsequent replacement when they become worn. Finally, because of the abrasive action to which they are subjected by virtue of the air having coal particles entrained therein striking thereagainst the bowl mill liners 44 are formed of a material that is noted for its good abrasion resistant qualities. Typically, the material from which the bowl mill liners 44 are formed, as cast, comprises, by weight percentages, 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum, and 0.015% nominal Bismuth.

The bowl mill liners 46 constructed as depicted in Figure 5 of the drawing are designed to be employed in the deflector portion 28 of the vane wheel assembly to which reference has been had hereinbefore in connection with the discussion of the bowl mill 10 shown in Figure 1. Namely, in accordance with the mode of construction of the deflector portion 28, the bowl mill liners 46 are designed to be employed therein as side liners. More specifically, the plurality of bowl mill liners 46 are utilized in the deflector portion 28 wherein each of the bowl mill liners 46 is installed so that the back edge thereof is arranged to be flush with the separator body 12 of the bowl mill 10 of Figure 1 and so that the bottom edge thereof is arranged to be flush with the intermediate liner (not shown). To this end, each of the bowl mill liners 46 embodies a configuration which is preestablished in order to enable each of the bowl mill liners 46 to be cooperatively associated one with another in a suitable fashion as required in order to function as an operative component of the deflector portion 28. That is, as best understood with reference to Figure 5 of the drawing, the bowl mill liner 46 embodies a configuration wherein a first side thereof, i.e., the side denoted by the reference numeral 46a in Figure 5, extends in a first plane, a second side thereof, i.e., the side denoted by the reference numeral 46b in Figure 5, extends in a second plane which is substantially perpendicular to the plane of the side 46a, a third side thereof, i.e., the side denoted by the reference numeral 46c in Figure 5, is inclined relative to the side 46a and in addition

extends in nonparallel relation to the side 46b of the bowl mill liner 46, and a fourth side thereof which includes a first portion, denoted by the reference numeral 46d in Figure 5, that extends in parallel relation to the side 46a of the bowl mill liner 46 and a second portion, denoted by the reference numeral 46e in Figure 5, that is inclined relative to the side 46c and in addition extends in nonparallel relation to the side 46a of the bowl mill liner 46. Because of the abrasive action to which they are subjected by virtue of the air having coal particles entrained herein striking thereagainst the bowl mill liners 46 are formed of a material that is noted for its good abrasion resistant qualities. Typically, the material from which the bowl mill liners 46 are formed, as cast, comprises, by weight percentages, 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum, and 0.015% nominal Bismuth.

The bowl mill liners 48 constructed as depicted in Figure 6 of the drawing are designed to be employed in the deflector portion 28 of the vane wheel assembly to which reference has been had hereinbefore in connection with the discussion of the bowl mill 10 shown in Figure 1. More specifically, in accordance with the mode of construction of the deflector portion 28, the plurality of bowl mill liners 48 are utilized in the manner of intermediate liners with which the deflector portion 28 is suitably provided. To this end, each of the bowl mill liners 48 embodies a configuration which is predetermined in order to enable each of the bowl mill liners 48 to be cooperatively associated one with another in a suitable fashion as required in order to function as an operative component of the deflector portion 28. That is, as best understood with reference to Figure 6 of the drawing, the bowl mill liner 48 includes a first portion denoted by the reference numeral 48a in Figure 6 which extends in a first plane, and a second portion denoted by the reference numeral 48b in Figure 6 which extends in a second plane that in turn is inclined at a predetermined angle to the plane of the first portion 48a. Because of the abrasive action to which they are subjected by virtue of the air having coal particles entrained therein striking thereagainst the bowl mill liners 48 are formed of a material that is noted for its good abrasion resistant qualities. Typically, the material from which the bowl mill liners 48 are formed, as cast, comprises, by weight percentages, 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum, and 0.015% nominal Bismuth.

Thus, in accordance with the present invention there has been provided articles that embody a wear resistant surface layer which is formed of a new and improved material that is characterized by its good wear resistant qualities. Moreover, the articles of the present invention embodying a wear resistant surface layer are particularly suited for employment in a bowl mill of the type which is designed to be utilized for purposes of effecting the pulverization therewithin of a material such as coal. In addition, in accord with the present invention the articles embodying a wear resistant surface layer include the grinding rolls which are designed to be employed in a bowl mill. Additionally, in accordance with the present invention the articles embodying a wear resistant surface layer include the bull ring which is designed to be emplaced on the grinding table of the bowl mill. Also, the articles of the present invention embodying a wear resistant surface layer include the liners which are designed to be selectively emplaced in those regions of the bowl mill that based on prior experience are known to be susceptible to wear. Furthermore, in accord with the present invention the articles embodying a wear resistant surface layer are relatively inexpensive to provide, are relatively easy to employ, and are characterized by their improved wear life.

While several embodiments of our invention have been shown, it will be appreciated that modifications thereof, some of which have been alluded to hereinabove, may still be readily made thereto by those skilled in the art. We, therefore, intend by the appended claims to cover the modifications alluded to herein as well as all the other modifications which fall within the true spirit and scope of our invention.

Claims

1. A grinding roll for use in a bowl mill comprising at least an outer surface layer formed of an abrasion resistant material having as cast a composition, by weight percentages, of 3.2% - 3.4% Carbon, 1.45% -1.65% Silicon, 0.4% maximum Manganese, 4.5% -5.0% Nickel, 4.0% -4.25% Chromium, 0.4% -0.5% Phosphorus, 0.9% -0.11% Sulfur, 0.4% - 0.5% Molybdenum and no Bismuth.

2. The grinding roll as set forth in Claim 1 further including a body portion formed of a relatively soft, easily machinable material.

3. The grinding roll as set forth in Claim 2 wherein said relatively soft, easily machinable material is gray iron.

4. The grinding roll as set forth in Claim 3 wherein said body portion has a through passage formed through substantially the center thereof.

5. An article for use in a bowl mill comprising at least an outer surface layer formed of an abrasion resistant material having as cast a composition, by weight percentages, of 3.5% -3.7% Carbon, 1.2% -1.6% Silicon, 0.4% maximum Manganese, 4.3% -5.0% Nickel, 3.7% -4.4% Chromium, 0.15% -0.25% Phosphorus, 0.9% -0.11% Sulfur, 0.4% -0.6% Molybdenum and 0.015% nominal Bismuth.

6. The article as set forth in Claim 5 wherein said article comprises a bull ring.

7. The article as set forth in Claim 6 wherein said bull ring is formed as a multiplicity of individual segments.

8. The article as set forth in Claim 6 wherein said bull ring is formed as a single integral member.

9. The article as set forth in Claim 5 wherein said article comprises a bowl mill liner.

10. The article as set forth in Claim 9 wherein said bowl mill liner includes first and second sides that extend in parallel relation one to another, a third side that extends substantially at right angles to each of said first and second sides, and a fourth side that is inclined at a predetermined angle to both said first and second sides and in addition extends in nonparallel relation to said third side.

11. The article as set forth in Claim 9 wherein said bowl mill liner includes a first side that extends in a first plane, a second side that extends in a second plane which is substantially perpendicular to said first plane, a third side that is inclined at a predetermined angle to said first side and in addition extends in a nonparallel relation to said second side, and a fourth side that includes a first portion which extends in parallel relation to said first side and a second portion that is inclined at a predetermined angle to said third side and in addition extends in nonparallel relation to said first side.

12. The article as set forth in Claim 9 wherein said bowl mill liner includes a first portion that extends in a first plane, and a second portion that extends in a second plane which in turn is inclined at a predetermined angle to said first plane.

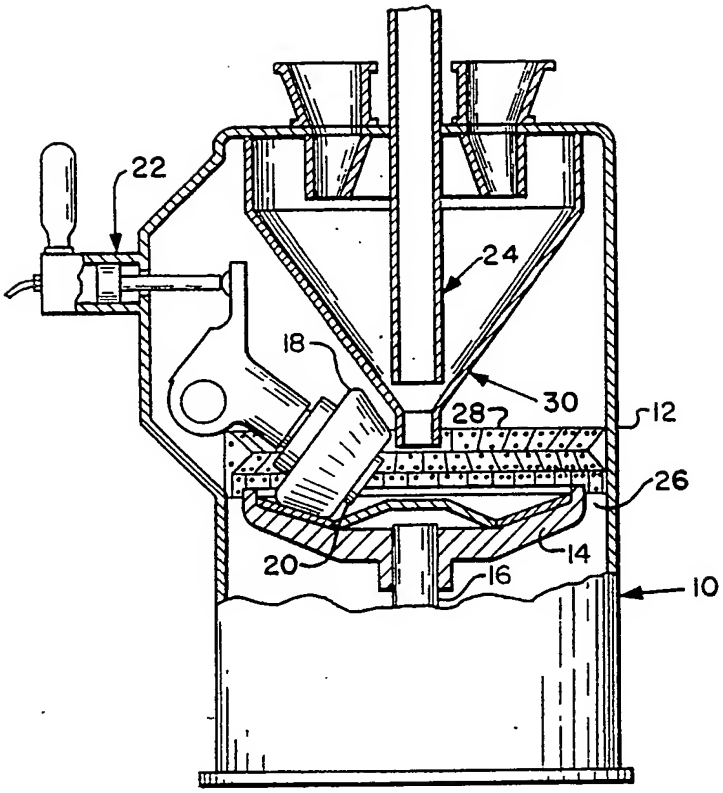

Fig. 1

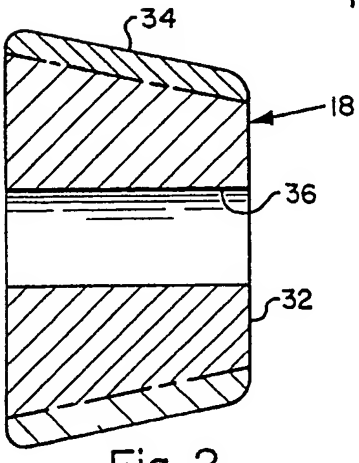

Fig. 2

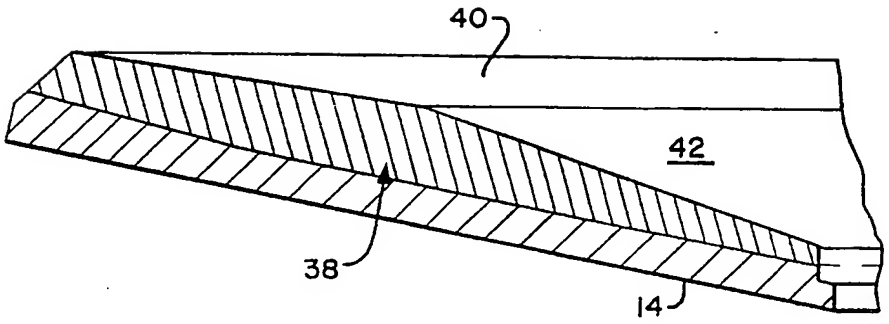

Fig. 3

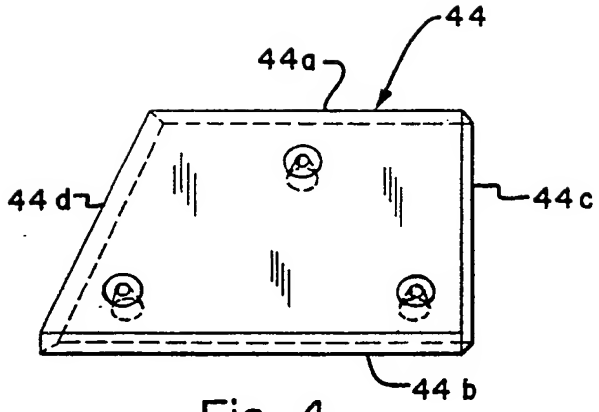

Fig. 4

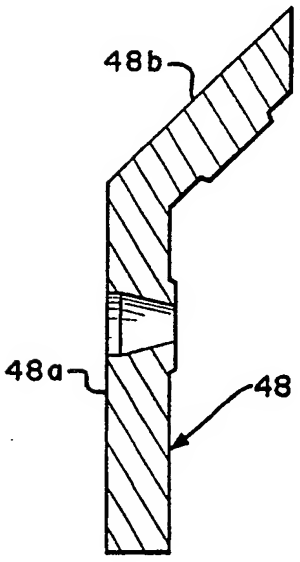

Fig. 6

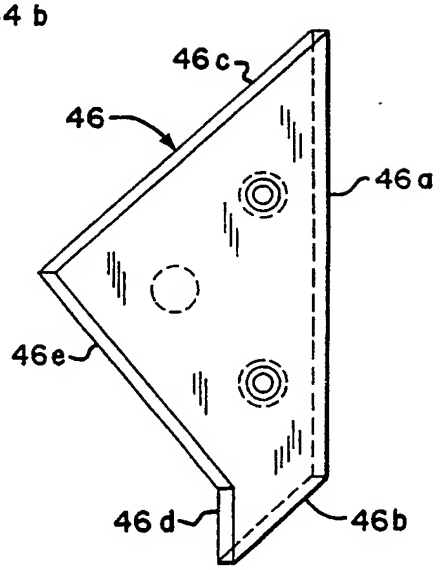

Fig. 5